

S-6/PHSH/CC-14/22

TDP (Honours) 6th Semester Exam., 2022

PHYSICS

(Honours)

FOURTEENTH PAPER : (CC-14)

Full Marks : 60

Time : 3 Hours

The figures in the margin indicate full marks.

GROUP—A

1. Answer any *six* questions : $2 \times 6 = 12$

- (a) Write the Planck's quantum hypothesis.
- (b) Write the Kirchhoff law in relation with the black-body radiation.
- (c) Define 'ensemble'.
- (d) What is phase space?
- (e) What is occupation index?
- (f) What do you mean by Fermi-Dirac statistics?
- (g) Define photon gas.
- (h) What is phase space? Write one of its importance.

(2)
GROUP—B

There are **four** questions from Question No. 2 to Question No. 5. Answer *either* (a) or (b) of each question.

2. (a) (i) How do you find the temperature of the Sun from the knowledge of solar constant and Stefan's law?
- (ii) What is Stefan's law? Give thermodynamic proof of Stefan's law.
- (iii) How can we derive the Wien's displacement law from Planck's law.

4+5+3=12

(OR)

- (b) (i) What is the spectral distribution of black-body radiation.
- (ii) Obtain Stefan's law of radiation from Planck's law, given that

$$\int_0^{\infty} x^3 e^{-ax} dx = \frac{6}{a^4}$$

- (iii) Derive the Planck's law of black-body radiation.

2+5+5=12

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[Continued]

(3)

3. (a) (i) Set a relation between the thermodynamic probability and entropy.

(ii) Derive the expression for the Maxwell Boltzmann distribution law.

(iii) Write the importance of partition function. 5+5+2=12

(OR)

- (b) (i) Define the physical significance of entropy. Why Gibbs paradox is called a paradox? Explain how the paradox was resolved.

(ii) State the law of equipartition of energy and prove this.

(iii) Give the basic concept of 'ensemble'. What are the different types of ensemble. (1+2+2)+(1+3)+(2+1)=12

4. (a) (i) Explain the need of introducing the quantum statistics.

(ii) Five bosons are distributed in two compartments, the first compartment is having 3-cell and the second 4. Find the thermodynamic probability for the macrostate (5,0).

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[Turn Over]

(4)

- (iii) What is Bose-Einstein condensation? When is a Bose gas said to be strongly degenerate? Calculate the energy of Bose-Einstein gas. $2+3+(2+2+3)=12$

(OR)

- (b) (i) Write the basic assumptions of Bose-Einstein quantum statistics.

- (ii) Derive the expression

$$n_i = \frac{g_i}{e^{(\alpha + E_i)/kT} - 1}$$

(The symbols have their usual meanings)

- (iii) Find the number of ways in which 3 bosons may be distributed in four-cell. Write the properties of liquid helium. $2+5+3+2=12$

5. (a) (i) Starting from Fermi-Dirac distribution law, derive the expression for energy distribution of free electrons in metal.

- (ii) When is Fermi gas said to be non-degenerate? In the limit $T \rightarrow 0$, find the mean occupation number of the single particle state.

(5)

- (iii) Show that $\langle n_e \rangle$ is a step function corresponding to the term $T=0$
 $5+2+3+2=12$

(OR)

- (b) (i) Using the expression for FD law of distribution of energy among electrons within a metal, prove that at 0°K —
(1) the average kinetic energy

$$\bar{u} = \frac{3}{5} u_f;$$

- (2) the average velocity $\bar{v} = \frac{3}{4} v_f$,

$u_f \rightarrow$ the Fermi energy.

$v_f \rightarrow$ The velocity of the electrons at the Fermi energy.

- (ii) Compare the distribution laws for MB, BE and FD statistics. Under what condition do the Bose-Einstein and Fermi-Dirac statistics yield classical result?

- (iii) How many ways can one distribute 9 unit of energy among 6 identical particles. What is the difference between identical and indistinguishable particles?

$$(3+2)+(2+2)+(2+1)=12$$

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